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GENETIC DIVERSITY ANALYSIS OF COMMON BEAN (*PHASEOLUS VULGARIS* L.) COLLECTED FROM NORTH WEST HIMALAYA FOR AGRO-MORPHOLOGICAL TRAITS

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ABSTRACT

Understanding of genetic diversity among the genotypes is the mainstay of plant breeding. The present study was carried out to determine genetic divergence among 59 common beans genotypes collected from North West Himalaya for nine agro-morphological traits. The analysis of variance depicted significant variability among genotypes for all the traits under study indicating wide range of variability present in bean genotypes. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was high for seed yield per plant followed by days to bud initiation. High heritability was also observed for all traits except pod length. Cluster analysis grouped bean genotypes into five distinct clusters. The genotypes under group II, III, V have more number of pods per plant, seeds per pod and single plant yield which can be utilized as potential donors for enhancing the yield of other genotypes in breeding programmes. Hence, the selection based on these yield contributing traits may helpful in future crop improvement programmes.

Keywords: genetic diversity analysis, morphological attributes, common bean, *Phaseolus vulgaris* L.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an annual herbaceous grain legume consumed globally. It belongs to family Fabaceae and has ability to fix atmospheric nitrogen in association with rhizobium bacteria. It is self-pollinated, diploid species with 11 pairs of chromosomes ($2n=2x=22$) and 473 Mb genome size (Schmutz *et al.*, 2014). Except Antarctica, it is grown in all continents as dry beans, shell beans and snap beans. In Latin America, it is one of the largest food components as well as consider under economically important crops (Pachico, 1989). For thousand years, beans have been the staple food in America along with maize and cassava. Globally, dry beans were grown on an area of 34.49 million hectares with production of 30.43 million tonnes (FAO, 2018).

The beans were domesticated 8000 years ago, which lead to formation of two gene pools: the Mesoamerican and the Andean. The Mesoamerican pool originated from Central America and Mexico with at least seven races while Andean originated from Andes mountains of South America (Gepts, 1998; Rodriguez *et al.*, 2015). These were differentiated on the basis of seed size, phaseolin (seed storage protein) patterns, plant morphology, isozymes, and

RFLP, RAPD, AFLP, and microsatellite markers (Gepts *et al.*, 1986; Koenig and Gepts, 1989a). The Mesoamerican gene pool possess small sized bean seeds with 'S' type phaseolin. On the other hand, Andean gene pool possess large sized bean seeds with 'T' type phaseolin (Gepts and Bliss, 1988). Out of 50 species known so far in the genus *Phaseolus*, only five are cultivated namely *Phaseolus vulgaris* (common bean), *Phaseolus lunatus* (lima bean), *Phaseolus acutifolius* A. Gray (teparay bean), *Phaseolus coccineus* L. (runner bean), and *Phaseolus dumosus* (= *polyanthus*) L. (yearlong bean)). Among them, *Phaseolus vulgaris* is most widely cultivated throughout the world (FAO, 2012).

Beans has good amount of calories and nutritional value. Along with calorie intake, it constitutes an important source of proteins, minerals (iron and zinc), vitamins, fiber, thiamine, folate, and phytochemicals with analgesic and neuroprotective properties (Blair *et al.*, 2013; Jha *et al.*, 2015). It can also be used as substitute for meat as 25-30% iron requirement can be met from beans. Being an inexpensive source of food, it is widely consumed by 300 million people in the tropics and 100 million people in Africa, thus regarded as 'poor man's meat' (Pachico, 1993). Beans are also an important component of

subsistence agriculture, hence also considered as ‘grain of hope’.

In India, dry beans are grown on an area of 13545518 ha with 6220000 tonnes of production and 4592 kg/ha yield (FAO, 2018). They are mainly cultivated in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Maharashtra, Karnataka and Andhra Pradesh. In Jammu and Kashmir, particularly Bhaderwah area, the beans are known for their unique flavour (Mahajan *et al.*, 2017). The beans herein possess wide range of genetic diversity with respect to market class, seed quality traits and adaptation, representing combination of both Mesoamerican and Andean cultivated gene pools (Akbulut *et al.*, 2013).

Genetic diversity study provide a way explore the potential of local germplasm, its adaptation, selection and use in crop improvement programmes including common bean. Moreover, identification of diverse genotypes gives an important insights about the potentiality of the genotypes to be used in breeding programmes (Emon and Ahammed, 2020). In the present study, the diverse bean germplasm was collected from North West Himalaya for nine agro-morphological traits. The different germplasm have been evaluated for morphological characteristics for identification of genetically diverse accessions to be used in common bean improvement programmes.

MATERIALS AND METHODS

Site description

Jammu and Kashmir is mainly comprises of two

geographical regions, namely Jammu region and Kashmir region north of the Indian Union comprise the extreme western part of the Himalayas (32.44°N and 74.54°E). The genotypes were mainly collected from from Jammu and Kashmir, Himachal Pradesh and Uttarakhand, besides National Bureau of Plant Genetic Resources (NBPGR), Shimla. The soil is clay loam with a slightly high pH is also present in temperate zone of Jammu and Kashmir.

Agro-morphological evaluation

The plant material used in this study comprised 59 accessions, of which 15 were from Bhaderwah (Jammu), one from Almora (Uttarakhand), one from Kupwara and Baramulla (Kashmir), one from Pulwama (Kashmir), two from Shopian (Kashmir), 13 from Poonch (Jammu), three from IIPR, Kanpur, 23 accessions including indigenous and exotic accessions from NBPGR, Shimla (Table 1). The collected diverse genotypes of common bean were grown in randomized block design (RBD) in three replications during the month of April-May with row length of 2m and spacing of 0.5m and harvested in August to September depending upon the maturity period of accessions. Evaluation was done for different agro-morphological traits at Regional Horticulture Research Sub Station, SKUAST-J, Bhaderwah (J&K) for two years 2018 and 2019. The farm is located at 32° 58' 45.88" N and 75° 43' 2.03" E and elevation of 1613m above sea level. The data was recorded for grain yield and its attributing traits like days to bud initiation, days to 50% flowering, days to fruiting, pod length, pod width, pods per plant, seeds per plant, 100 seed weight and seed yield per plant. The days to flowering (number of days taken from sowing to

Table 1: List of bean genotypes used in the present study with their location

S. No.	Germplasm	Location/Source
1	BR 1, BR 2, BR 3, BR 7, BR 9, BR 10, BR 15, BR 16, BR 18, BR 22, BR 26, BR 31, BR 36, BR 39, BR 55	Bhaderwah, J&K
2	EC-398527, EC-398587, EC- 894826, EC-400433, EC- 530898, EC- 405220, IC- 274530, IC- 258273, IC- 260312 , IC- 260336, IC- 260299, IC- 199277, IC- 260343, EC-398591, IC- 361884, EC-400397, IC- 202271, IC- 258276, IC- 243198, EC- 755305 , IC- 202274, IC- 043562, IC- 262769	NBPGR, Shimla, H.P.
3	VL 63	Almora, Utrrakhand
4	KB1	Kupwara & Baramula, J&K
5	PL1	Pulwama, J&K
6	S4, S6	Shopian, J&K
7	P1, P2, P4, P6, P7, P14, P15, P17, P22, P27, P28, P29, P33	Poonch, J&K
8	Hur-137, Utkarsh, Arun	IIPR, Kanpur, U.P.

Where, BR= Bhaderwah; EC= Exotic collection; IC=Indigenous collection; VL=VPKAS, Almora; KB= Kupwara & Baramula; PL= Pulwama; S= Shopian; P= Poonch.

Table 2: Mean performance of morphological traits of beans (*Phaseolus vulgaris* L.) under study

Genotypes	Days to bud initiation	Days to 50% flowering	Pod length (cm)	Pod width (mm)	Days to fruiting	Total number of pods per plant	Total number of seeds per plant	100 seed weight (g)	Seed yield per plant (g)
P1	80.00	87.00	12.26	2.60	98.00	17.33	89.00	28.63	25.50
P2	67.33	75.00	10.73	3.03	82.00	9.00	60.66	43.33	26.30
P4	73.33	82.33	11.60	2.16	91.00	16.00	97.00	26.43	25.62
P6	68.33	76.00	10.50	2.56	84.00	13.66	96.33	16.00	15.41
P7	68.00	76.00	11.43	2.80	84.00	19.00	127.00	22.50	28.57
P14	70.00	78.00	11.53	2.70	86.00	8.00	44.00	28.33	12.46
P15	73.00	80.00	12.53	2.76	88.00	18.66	108.00	25.50	27.53
P17	64.33	71.00	11.83	2.26	78.00	16.33	92.66	26.33	24.41
P22	67.33	73.33	11.73	2.46	82.00	15.00	92.00	26.16	24.07
P27	62.33	70.00	13.13	2.86	76.00	12.33	83.00	24.00	19.92
P28	70.00	76.00	10.90	2.66	81.00	11.00	72.00	24.56	17.68
P29	67.00	75.00	11.83	2.46	83.00	14.33	87.66	24.46	21.43
P33	64.33	70.66	12.06	2.63	78.00	15.66	102.33	28.60	29.26
PL1	73.33	81.33	14.20	2.96	90.00	10.33	70.66	21.66	15.33
IC-202274	45.33	52.00	8.20	2.76	60.00	20.66	130.66	19.66	25.70
EC-755305	46.33	54.00	9.36	2.16	62.00	15.00	86.00	27.33	23.51
IC-199277	48.66	56.00	10.50	2.16	63.00	20.00	129.00	22.83	29.46
IC-260312	48.66	54.00	11.76	2.56	61.00	13.33	101.33	27.33	27.69
IC-260343	46.66	54.00	10.43	3.20	61.00	12.33	78.33	21.50	16.86
EC-894826	51.00	57.00	10.83	2.23	64.00	20.33	130.00	34.83	45.30
IC-202271	53.33	59.66	11.96	2.60	67.00	15.66	88.00	27.50	24.21
EC-400433	47.00	54.00	11.76	2.50	60.00	17.33	102.66	25.80	26.50
IC-260299	49.66	55.00	11.96	2.93	61.00	16.33	98.33	28.23	27.76
IC-243198	48.33	56.00	11.83	2.20	61.66	16.00	96.00	30.10	28.89
EC-398527	49.00	54.00	12.46	2.36	61.00	14.00	75.66	21.43	16.21
EC-400397	49.33	55.33	12.26	2.50	63.00	12.66	75.66	26.00	19.65
EC-398587	47.33	53.00	11.63	2.50	60.00	14.66	90.66	30.33	27.60
EC-398591	45.00	50.00	11.80	2.16	56.00	14.66	84.00	24.66	20.72
IC-274530	49.33	56.00	11.73	2.46	63.00	15.00	91.33	27.83	25.43
EC-405220	47.00	52.00	12.50	2.36	58.00	16.33	97.66	30.00	29.31
IC-262769	45.33	49.66	11.83	2.36	56.00	19.66	109.66	32.00	35.11
IC-258273	75.00	86.00	11.13	2.66	97.00	14.00	80.33	22.50	18.09
IC-260336	72.00	79.00	10.63	2.66	89.00	16.00	87.00	29.50	25.68
IC-361884	72.00	80.00	13.33	3.06	89.00	18.00	96.66	34.83	33.69
IC-043562	68.00	79.00	9.96	2.50	87.00	16.66	95.33	25.06	23.88
EC-530898	73.00	82.00	12.06	2.70	88.00	16.33	88.33	27.30	24.14
IC-258276	48.33	55.33	11.70	2.16	63.00	16.66	94.00	30.83	29.00
BR1	65.00	74.00	10.43	2.30	82.00	16.00	91.00	22.00	20.02
BR2	60.00	69.00	8.23	2.96	75.00	20.00	119.33	21.33	25.45
BR3	81.00	88.00	11.90	2.83	96.00	13.66	102.66	28.33	29.10
BR7	75.00	82.00	12.40	2.46	83.00	13.00	72.66	21.93	15.93
BR9	65.00	72.00	11.63	2.36	80.00	17.33	100.33	29.66	29.79
BR10	89.00	81.00	12.23	2.36	87.00	12.00	81.66	24.50	19.98
BR15	72.00	79.00	11.80	2.50	86.00	14.66	82.66	21.96	18.15
BR16	74.00	81.00	12.10	2.96	82.00	18.66	100.00	20.10	20.14
BR18	73.00	83.00	11.40	2.96	91.00	15.33	89.33	27.63	24.71

Continued...

BR22	74.00	83.00	13.13	2.86	90.00	17.33	107.00	29.50	31.58
BR26	70.00	75.00	11.26	2.50	82.00	14.66	88.66	23.33	20.69
BR31	75.00	84.00	13.36	2.80	89.00	18.00	111.00	30.83	34.22
BR36	62.00	69.00	11.96	2.26	73.00	17.33	104.00	29.83	31.06
BR39	75.00	84.00	13.30	2.66	92.00	15.66	88.33	34.40	30.39
BR55	74.00	82.00	12.50	2.33	88.00	16.00	83.66	20.83	17.47
S4	46.00	52.00	9.56	2.60	60.00	10.66	65.66	24.33	15.97
S6	70.00	79.00	11.00	2.50	87.00	16.33	93.33	25.00	23.30
KB1	69.00	73.00	12.60	2.73	80.00	15.00	82.00	23.33	19.14
VL63	74.00	84.00	10.06	2.76	91.00	12.33	65.00	25.80	16.77
HUR137	50.00	59.00	12.43	2.40	69.00	13.66	83.66	21.66	18.17
UTKARSH	48.00	54.00	12.90	2.60	61.00	13.33	81.33	24.00	19.52
ARUN	56.00	62.00	11.13	2.50	69.00	15.33	97.00	25.56	24.80

Table 3: Variability parameter estimates for various characters in common beans

Characters	Mean \pm SE	C.D	C.V	Range	Coefficient of variation (%)		Genetic advance	Genetic advance as % of mean	Heritability (Broad sense) (%)
					PCV	GCV			
Days to bud initiation	62.56 \pm 1.72	2.07	2.04	45.00-89.00	19.10	19.06	3.50	5.59	0.99
Days to 50% flowering	69.55 \pm 1.94	2.35	2.09	49.66-88.00	17.77	17.72	3.95	5.67	0.99
Days to fruiting	76.68 \pm 2.07	3.22	2.59	56.00-98.00	16.48	16.41	4.22	5.50	0.99
Pod length	11.85 \pm 0.41	5.23	27.25	8.20-13.30	19.07	10.88	0.26	2.19	0.31
Pod width	2.57 \pm 0.05	0.11	2.78	2.16-3.20	9.72	9.72	0.10	3.89	0.98
Pods/plant	15.33 \pm 0.64	1.27	5.13	8.00-20.66	17.74	17.48	1.27	8.28	0.97
Seeds/plant	91.85 \pm 1.94	4.67	3.14	44.00-130.66	18.06	17.96	3.91	4.25	0.98
100 seed weight	26.26 \pm 0.35	0.95	2.24	16.00-43.33	17.09	17.06	0.71	2.70	0.99
Seed yield/plant	24.14 \pm 0.75	1.59	4.06	12.46-45.30	25.10	24.97	1.52	6.29	0.99

50% of plants on plots had at least one open flower), days to bud initiation (number of days taken from sowing to formation of buds) and days to fruiting (number of days taken from sowing to first pod set after sowing) were recorded in the field on plot basis. Pod length from five randomly selected pods of each tagged plant was measured from base of the pod to the tip of pod using thread and scale and the observations were averaged for each tagged plant. The average mean of values of each tagged plants was calculated. The pod width was measured from the middle portion of the pod and the averaged width was worked out. The number of pods from each picking of every tagged plant was recorded and the average of total number of pods per plant was calculated. The number of seeds from three tagged plants in each replication were

counted and averaged. The seeds were harvested and the total weight of 100 seeds of each genotype was measured and recorded. The weight of seeds of each tagged plant in a block was measured in grams and averaged to get the seed yield per plant.

Statistical analysis

The pooled analysis of variance for nine traits was performed and analysed. Phenotypic and genotypic coefficients of variation (PCV and GCV) for each trait were calculated as $PCV = \sqrt{V_p}/\text{mean} \times 100$, $GCV = \sqrt{V_g}/\text{mean} \times 100$ as per (Burton, 1952) and categorized the range as per Sivasubramanian and Madhavamenon, (1978). Broad sense heritability was estimated as $h^2 (bs) =$

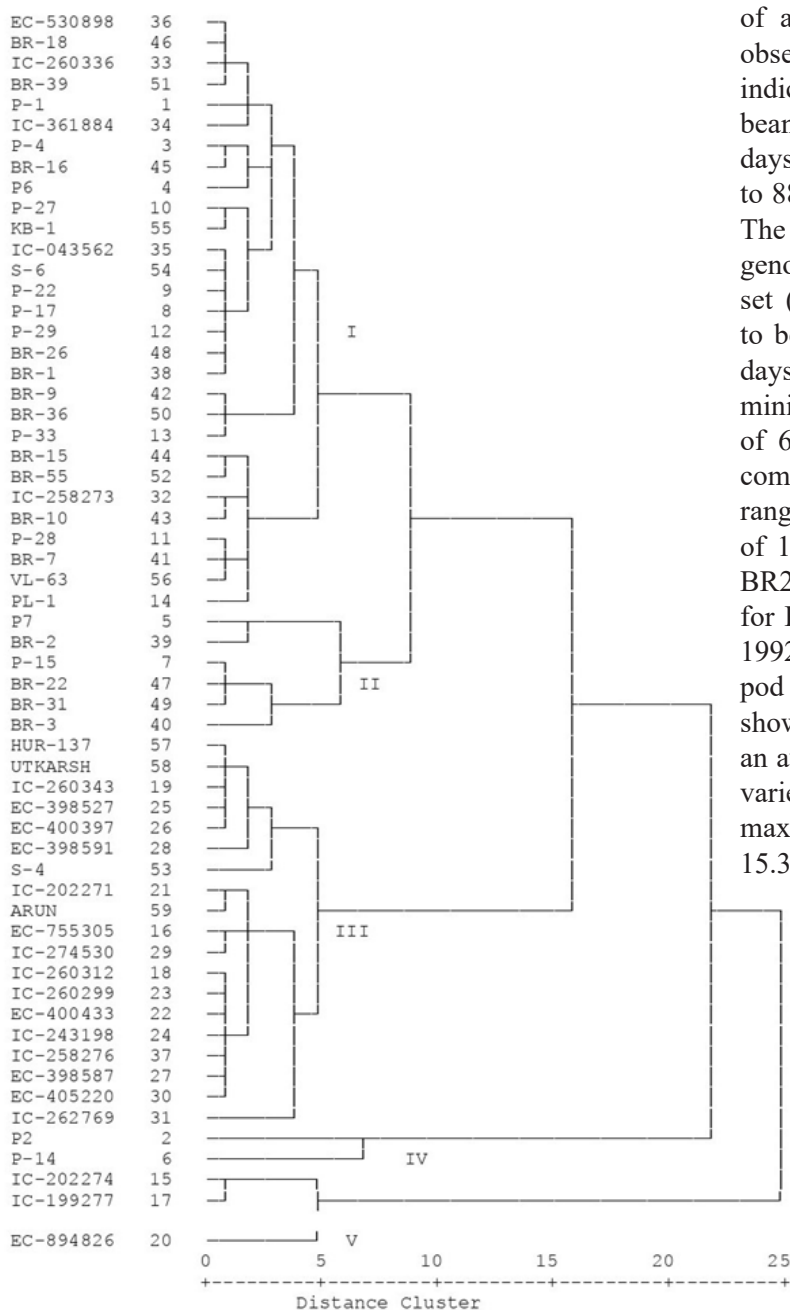


Fig. 1. Phylogenetic relationships of 59 genotypes of common bean for agro-morphological traits.

$V_G/V_p \times 100$ as per (Lush, 1940) and further classified into low, medium and high (Johnson *et al.*, (1955). Expected as $EGA = k \times V_G/V_p \times \sqrt{V_p}$ as per Johnson *et al.*, (1955). Here the standard value of k is 2.06 assumed at 5 % selection intensity; V_G is genotypic variance; and V_p is phenotypic variance. Genetic advance was expressed as % of mean as $GA (\%) = EGA/\text{mean} \times 100$. The significance of variances was tested at the 5% probability level. One factor ANOVA analysis of variance was performed using OPSTAT and ward's clustering methods with squared Euclidean distance were performed with software Statgraphics Plus and SAS 9.3.

RESULTS AND DISCUSSION

The magnitude of variability present in a population is primary requirement for screening of superior genotypes in any crop improvement programmes. On the basis

of analysis of variance, significant differences were observed among genotypes for the traits under study indicating wide range of genetic variability present in bean genotypes (Table 2). The mean performance for days to flowering varied from 49.66 days in IC-262769 to 88 days in BR3 with overall general mean of 69.55. The data obtained for days to fruiting showed that genotype EC-398591 and IC-262769 had early pod set (56) and genotypes P1 took maximum days (98) to bear fruit with overall general mean of 76.68. The days to bud formation was maximum in BR10 (89) and minimum in EC-398591 (45) with an average mean of 62.56 in bean genotypes. Pod length in collected common bean germplasm showed a wide variation ranging between 8.2 cm and 14.2 cm with an average of 11.85 cm size. The shortest pod was recorded for BR2 and IC-202274 genotype and longest pod seen for PL1 genotype. Further, genotypes EC-755305, IC-199277, EC-398591, IC-258276 showed the minimum pod width of 2.16 cm whereas genotype IC-260343 showed the highest value for pod width of 3.2 cm with an average mean of 2.57 cm pod width. Pods per plant varied from 8 to 20.66 with minimum found in P14 and maximum obtained for IC-202274 with an average of 15.33 pods per plant recorded. Genotype P14 showed minimum seeds per plant while maximum was recorded for genotype IC-202274. The values varied from 44 to 130.66 with an average of 91.85. 100 seed weight trait ranged between 16 g in case of P6 to 43.33 g in case of P2 with an average of 26.25 g. The average seed yield per plant was 24.14 g ranging between 12.46g and 45.3g with minimum obtained for P14 and maximum for EC-894826.

Mean \pm SE and ranges for the bean genotypes depicts significant variation in yield attributing

traits like days to bud initiation, days to 50% flowering, days to fruiting, pod length, pod width, seeds/plant, pods/plant, 100 seed weight, seed yield per plant. These results were concordance with studies of Salgotra *et al.*, (2002, 2012), Bralewski *et al.*, (2007), Horňáková *et al.*, (2003), Stoilova *et al.*, (2005, 2013), Das, (2005), Casquero *et al.*, (2006), Boros *et al.*, (2014). The mean \pm SE, range, coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean of yield and yield attributing traits were given in Table 3. The GCV and PCV depict extent of genetic variation. There was very small difference between GCV and PCV for characters all the characters except pod length indicating influence of genetics over these characters. Similar results were reported by Salehi *et al.*, (2008) and Anunda *et al.*, (2019). On the other hand, there was a large difference between GCV and PCV in case of pod length indicating role of environment in expression of this character, hence, its selection may not be effective (Verma *et al.*, 2014). The magnitude of PCV and GCV were high in seed yield per plant. Similar results were reported by Stoilova *et al.*,

(2004), Kamaluddin, (2011) and Alemu *et al.*, (2013). Further, moderate for days to bud initiation, days to 50% flowering, days to fruiting, pod length, seeds/plant, pods/plant, 100 seed weight; and low for pod width. PCV for seed yield per plant was 25.10 while for pod width 9.72. GCV for seed yield per plant was 24.97 while lowest were for pod width 9.72. The PCV was higher than GCV for all traits indicating phenotypic variation as a result of effect of genotype and environmental influence (Singh 1999; Anunda *et al.*, 2019; Ghosh *et al.*, 2010).

Estimates of heritability in broad sense of the 9 quantitative traits ranged from 0.31% for pod length to 0.99% for days to bud initiation, days to 50% flowering, days to fruiting, 100 seed weight, seed yield/plant. High heritability was also observed for traits like pod width (0.98%), pods/plant (0.97%), and seeds per plant (0.98%). Similar results were reported for pod yield/plant and pods/plant by Rai *et al.*, (2010), Junaif *et al.*, (2010), Devi *et al.*, (2015). This is in contrary to results reported by Hassan *et al.*, (1995) where high heritability for pod length (91%) and low (48%) for pods per plant was reported. High heritability and genetic advance was reported for pods per plant by Sawant, (1994) and Ram *et al.*, (1994). Genetic advance varied from 0.10 for pod width to 4.22 for days to fruiting. Genetic advance as percentage of mean ranges from 2.19 for pod length to 8.28 for pods per plant. All variables had low genetic advance as well as genetic advance as percentage of mean. Singh *et al.*, (2000); Salgotra *et al.*, (2009); Pande *et al.*, (1973); Alemu *et al.*, (2013) reported low genetic advance for days to 50% flowering.

Cluster analysis

The cluster analysis based on nine yield attributing traits grouped 59 bean genotypes into five distinct clusters with 29 genotypes in group I, 6 in group II, 19 in group III, 2 in group IV, and 3 in group V (Fig. 1). The genotypes in group I viz EC- 530898, BR18, IC- 260336, BR39, P1, IC- 361884, P4, BR-16, P6, P27, KB1, IC- 043562, S6, P22, P17, P29, BR26, BR1, BR9, BR36, P33, BR15, BR55, IC- 258273, BR10, P28, BR7, VL63 and PL1 had late days to bud initiation, days to 50% flowering, days to fruiting and high seeds per plant. The genotypes in group II viz P-7, BR-2, P-15, BR-22, BR-31 and BR-3 had high pod length, pod width, number of pod per plant, seeds per pod and seed yield per plant. The genotypes in group III viz HUR137, Utkarsh, IC-260343, EC-398527, EC-400397, EC-398591, S4, IC-202271, Arun, EC-755305, IC- 274530, IC- 260312, IC- 260299, EC- 400433, IC-243198, IC- 258276, EC- 398587, EC- 405220 and IC-262769 had early days to bud initiation, days to 50% flowering, days to fruiting, high number of pods per plant, seeds per plant and seed yield per plant. The genotypes in group IV viz P2 and P14 had less number of pods per plant and seeds per plant. The genotypes in group V viz IC-202274, IC-199277, EC-894826 had early days to bud initiation, days to 50% flowering, days to fruiting, and

high pods per plant and seeds per plant. The selection of diverse parents should be based on the yield characters that lead to enhanced gene pool with wider adaptation (Sandhu *et al.*, 2006). The genotypes under group II, III, V had more number of pods per plant, seeds per pod and single plant yield can be utilized as potential donors for enhancing the yield of other genotypes in breeding programmes. The accessions with same origin did not cluster in same group. These results are in accordance with Madakbas and Ergin, (2011), Boros *et al.*, (2014) and Rai *et al.*, (2016) where landraces with same origin did not cluster together. Boros *et al.*, (2014) reported 5 groups in bean accessions where genotypes from group I and II were very useful for breeding purpose.

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